CURRENT LITERATURE

NOTES FOR STUDENTS

Niter spots.—The occupation and cultivation of vast areas of semi-arid lands in Utah, Wyoming, and Colorado, which has been made possible by the development and extension of irrigation systems, has brought agricultural workers in these states face to face with many new problems. Possibly none of these has been more striking than that presented by the sudden appearance in the soil of nitrate accumulations in amounts sufficient to produce complete sterility over considerable areas which had previously been normally productive. Since the areas thus affected are widely scattered and embrace some of the most valuable agricultural lands of these states, the search for the causes of the condition has occupied the attention of a number of workers, and a very considerable literature, some of which borders upon the controversial in character, has resulted.

HEADDEN, who has been longest engaged in studies of the problem, was first to call attention to the extent and gravity of the condition, and to point out that most cases of sudden destruction of orchards, while popularly attributed to "black alkali" (sodium carbonate) from irrigation waters, were in reality due to nitrate accumulation. Contrary to HILGARD,[1] who attributed an increase in nitrates observed in certain irrigated soils of southern California to rapid transformation of organic matter previously accumulated in the soil, HEADDEN[2,3] has advanced the theory that fixation of atmospheric nitrogen by *Azotobacter*, with concurrent bacterial transformation of the resulting nitrogenous compounds into nitrates, is responsible for these accumulations. This author has shown that orchard trees, alfalfa, or other crops in the affected areas uniformly show characteristic injury quite unlike that produced by excessive irrigation or by sodium carbonate or other alkali salts, but identical with that produced by excessive use of nitrate fertilizers. He also attributes the rather widespread deterioration in yield, sugar content, and keeping qualities of sugar beets to accumulation of nitrates in the soil.[4]

[1] HILGARD, E. W., Soils. New York: Macmillan. 1911. pp. 68, 69.

[2] HEADDEN, WM. P., The fixation of nitrogen in some Colorado soils. Bull. Colorado Agric. Exper. Sta. no. 155. pp. 10–69. 1910.

[3] ———, Nitrates in the soil; an explanation of so-called "black alkali" or "brown spots." Bull. Colorado Agric. Exper. Sta. no. 160. pp. 1–8. 1910.

[4] HEADDEN, WM. P., Deterioration in the quality of sugar beets due to nitrates formed in the soil. Bull. Colorado Agric. Exper. Sta. no. 183. pp. 1–184. 1912.

HEADDEN'S studies of the chemical composition of "niter spots"[5, 6, 7, 8] have shown that, in many cases, nitrates may be present in the first foot of the soil in amounts approximating 133 tons per acre-foot, while in many cases nitrate accumulation is progressing at rates varying between 2 and 22 tons annually per acre-foot. It is HEADDEN'S contention that the quantities of nitrates found bear no constant ratio to the amounts of chlorides or carbonates present or to the total water-soluble salt content, and that the high nitrate content is confined to the first few inches of the soil, and he regards these facts, together with the extent of the affected areas and their dissimilar geological relations, as strong evidence against the theory that the condition can be due to seepage from nitrate-bearing rocks with subsequent deposition from surface evaporation.

SACKETT[9, 10] has attacked the problem from the bacteriological side and has presented evidence that *Azotobacter* is present in large numbers in irrigated soils, and that fixation of nitrogen occurs at exceptionally high rates in soils from "niter spots"; while ROBBINS[11] has shown that these soils are unusually rich both in species and numbers of Cyanophyceae, which may be considered as supplying carbohydrates available as a source of energy for *Azotobacter*. SACKETT further concludes from his studies of the ammonifying and nitrifying efficiency of Colorado soils[12, 13] that ammonification and nitrification proceed in them at rates considerably in excess of those found by workers in other parts of the United States. It must be said in criticism of SACKETT'S work that, while his own ammonification cultures were in all cases continued for a period of seven days, he has compared the amounts of ammonia produced therein

5 HEADDEN, WM. P., The fixation of nitrogen in some Colorado soils; a further study. Bull. Colorado Agric. Exper. Sta. no. 178. pp. 1–96. 1911.

6 ———, The fixation of nitrogen in Colorado soils; the distribution of the nitrates and their relation to the alkalies. Bull. Colorado Agric. Exper. Sta. no. 186. pp. 1–47. 1913.

7 ———, The excessive quantities of nitrates in certain Colorado soils. Jour. Indust. and Eng. Chemistry **6**:586–590. 1914.

8 ———, Do Azotobacter nitrify? Science N.S. **40**:379–381. 1914.

9 SACKETT, WALTER G., Bacteriological studies of the fixation of nitrogen in certain Colorado soils. Bull. Colorado Agric. Exper. Sta. no. 179. pp. 1–42. 1911.

10 ———, Bakteriologische Untersuchungen über die Stickstoffbindung in gewissen Bodenarten von Colorado. Centralbl. Bakt. **34**^{2}:81–115. 1912 (German translation of previously published paper just cited).

11 ROBBINS, W. W., Algae in some Colorado soils. Bull. Colorado Agric. Exper. Sta. no. 184. pp. 24–36. 1912.

12 SACKETT, WALTER G., The ammonifying efficiency of certain Colorado soils. Bull. Colorado Agric. Exper. Sta. no. 184. pp. 1–23. 1912.

13 ———, The nitrifying efficiency of certain Colorado soils. Bull. Colorado Agric. Exper. Sta. no. 193. pp. 1–43. 1914.

directly with amounts found by other workers for similar cultures run for various shorter periods, as four or six days. Such results are in no wise comparable, since the initial rate of ammonification is normally low, but increases rapidly through the first six to ten days of incubation.

In the determinations of nitrifying efficiency, SACKETT employed soils obtained from various parts of the United States as checks upon soils from different portions of the state. Here the Colorado soils were collected under uniform conditions and with bacteriological precautions, while those from other states were taken by persons unfamiliar with bacteriological technique or with methods employed in soil sampling, and were subsequently shipped for long distances in widely varying types of containers. While the author deplores the failure to employ standard methods, he nevertheless draws rather sweeping conclusions as to the comparative ammonifying and nitrifying efficiencies of the two lots of soils, and asserts that the experiments demonstrate the presence in Colorado soils of a nitrifying flora distinct, either in species or in physiological efficiency, from that elsewhere found. It would seem to the reviewer that definite conclusions are not in order until concordant results have been obtained from repeated studies in which all possibility of variation in any significant factor has been eliminated. The necessity for caution is especially great here in view of the fact that the work of KELLERMAN and ALLEN[14] in Nevada, while showing the presence of large numbers of nitrifying and ammonifying bacteria, yields no indication of abnormally high rates of activity or of unusual activity of *Azotobacter;* while the more recent work of MCBETH and SMITH, to be presently discussed, is wholly confirmatory of the results obtained by KELLERMAN and ALLEN.

At the Utah Experiment Station, the problem has been attacked by STEWART and his co-workers. In the course of their very thorough studies of the production and movement of nitrates in the soils of the Greenville farm[15, 16, 17] STEWART and GREAVES reached the conclusion that bacterial action could not be responsible for the accumulation of any large quantities of nitrates at the surface of the soil, at least in irrigated areas, since nitrates are readily displaced into the deeper layers of the soil by the downward movement of irrigation water. In more than 30,000 determinations of nitric nitrogen,

[14] KELLERMAN, KARL F., and ALLEN, E. R., Bacteriological studies of the soils of the Truckee-Carson irrigation project. Bull. U.S. Dept. Agric., Bur. Pl. Industry. no. 211. pp. 1–36. 1911.

[15] STEWART, ROBERT, and GREAVES, J. E., A study of the production and movement of nitric nitrogen in an irrigated soil. Bull. Utah Agric. Exper. Sta. no. 106. pp. 67–96. 1909.

[16] ———, The movement of nitric nitrogen in soil and its relation to "nitrogen fixation." Bull. Utah Agric. Exper. Sta. no. 114. pp. 181–194. 1911.

[17] ———, The production and movement of nitric nitrogen in soil. Centralbl. Bakt. **34**^{2}:115–147. 1912.

extending over a period of eight years, these workers never found a nitric nitrogen content exceeding 300 pounds per acre for a total depth of ten feet. STEWART has also studied the rate at which nitrification occurs in this soil,[18] with results which indicate that the conditions rarely if ever permit this process to become intense, a conclusion in entire accord with the results of McBETH and SMITH.[19]

The extensive and carefully controlled work carried on by these investigators for the past four years at the Greenville Experiment farm has shown that nitrification is practically confined in all cases to the first foot of the soil; that the application of irrigation water invariably diminishes the nitrifying power of the soil; that the water-content of non-irrigated soil, in a region having a well-distributed annual rainfall of 15.81 inches, is entirely too low throughout the summer months to permit of active nitrification; and that the nitrification process is markedly inhibited by the addition to the soil of small quantities of ammonium sulphate (170 ppm.). The scale on which these experiments were conducted, the attention given to the control of the experimental conditions, and the entire accordance of the data obtained for the four-year period, would apparently entitle the results of these authors to acceptance as conclusive.

STEWART and his associates have advanced the theory that abnormal accumulations of nitrates, wherever these may occur in the area which was submerged during later Cretaceous time, are due to transportation and deposition of leachings from the country rock, adducing proof that throughout Utah, Idaho, and Colorado, it is quite generally the case that the chlorine content of "niter spots" increases proportionately with the increase in nitrates, which they regard as conclusive evidence of a common origin of these elements. By recalculation of data presented by HEADDEN, these authors have shown that fairly definite ratios of increase between chlorine and nitrate hold for the Colorado nitrate areas, in one of which the supposed "fixation" of 621 pounds of nitrogen was accompanied by an increase of 236,883 pounds in the chlorine content of the first acre-foot! That any material activity on the part of nitrifying bacteria can occur in the presence of the amounts of chlorine shown by STEWART and GREAVES to be present in the soils studied by HEADDEN would seem impossible to the reviewer in view of the results of LIPMAN.[20] That *Azotobacter* can be responsible for an increase in soil nitrates which has been shown to occur at rates frequently exceeding 5000 pounds per acre-foot annually would seem equally impossible, since there would be required to supply the

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[18] STEWART, ROBERT, The intensity of nitrification in arid soils. Centralbl. Bakt. **36**^{2}:477–489. 1913.

[19] McBETH, I. G., and SMITH, N. R., The influence of irrigation and crop production on soil nitrification. Centralbl. Bakt. **40**^{2}:24–51. 1914.

[20] LIPMAN, C. B., Toxic effects of alkali salts on soils on soil bacteria. II. Nitrification. Centralbl. Bakt. **33**^{2}:305–326. 1912.

necessary energy, under optimum conditions, at least 100 pounds of carbohydrate for every pound of nitrate formed.[21] Under no conceivable conditions could the algal flora of a soil supply any substantial portion of the 250 tons of dextrose needed for such fixation.

The most recent contribution to the subject is a study of the nitrate content of the country rock by STEWART and PETERSON.[22] While working primarily in Utah, these authors have collected and analyzed large numbers of sandstones, limestones, and shales from widely separated localities throughout Utah, Wyoming, and Colorado. These may be considered fairly representative of the country rocks occurring in the area covered by the cretaceous and tertiary seas. They find that while the Jurassic sandstones and shales are not characterized by an unusually high nitrate content, the cretaceous and tertiary sandstones everywhere contain nitrates far in excess of the quantities present in ordinary alkali-free soils, often to the amount of one to ten tons per acre-foot; while the tertiary shales have prevailingly an even higher nitrate content. Over very extensive, wholly barren areas of virgin "clay hill" soil there is present beneath the compact, impermeable surface clay a layer of ash-like material, two to six inches in thickness, bearing 0.15 to 0.20 per cent of sodium nitrate, an amount equal to 900 to 36,000 pounds per acre-foot. The authors estimate the total nitrate content of the Book Cliffs area in Utah and Colorado as being many times greater than that of the deposits of Chile, but have nowhere found concentrations of such extent and character as would permit them to be profitably worked, a situation resembling that found by FREE[23] in southern California. STEWART and PETERSON consider that the discovery that nitrate deposits are not confined to the shales, but are generally present in the country rock, and that their amounts are everywhere materially greater than has been hitherto supposed, constitutes conclusive proof that "niter spots" are accumulations resulting from leaching, and have no relation to bacterial activities in the soil. In view of the very large accumulation of evidence against the latter hypothesis and the conclusive character of the results obtained by STEWART and his co-workers, this conclusion would appear to be wholly justified.—JOSEPH S. CALDWELL.

Some temperature effects.—In discussing some of the phytogeographic effects of winter temperature, SHREVE[24] calls attention not only to the great lack of critical data, but more especially to the fundamental error, so prevalent

[21] MARSHALL, C. E., Microbiology. Philadelphia: Blakiston & Co. 1912. pp. 272–273.

[22] STEWART, ROBERT, and PETERSON, WILLIAM, The nitric nitrogen content of the country rock. Bull. Utah Agric. Exper. Sta. no. 134. pp. 420–465. 1914.

[23] FREE, E. E., Nitrate prospects in the Amargosa valley, near Tecopa, Cal. Circular U.S. Dept. Agric., Bur. Soils. no. 73. 1912.

[24] SHREVE, F., The rôle of winter temperature in determining the distribution of plants. Amer. Jour. Bot. 1:193–202. 1914.